

UNITED STATES PATENT SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT, I, Kenji YONEDA, of Japanese Nationality,  
residing at Saganohaitsu 518, 26 Sagano Shibano-cho, Ukyo-ku,  
Kyoto-shi, Kyoto 616 JAPAN, has invented certain new and useful  
improvements in

METHOD OF MANUFACTURING A LIGHTING UNIT FOR INSPECTING A SURFACE  
of which the following is a specification.

## **BACKGROUND OF THE INVENTION**

This invention relates to a method of manufacturing a lighting unit which is preferably used when a product inspection is conducted using reflected light emitted by the lighting unit.

Methods of using lighting units to examine a surface of a product have generally been known. In these methods, the surface of the product to be examined is irradiated through an underside of the lighting unit, and the reflected light is visually inspected or photos of the surface are taken in close proximity to the lighting unit. If some unevenness exists in the light intensity on the surface being examined, it may indicate that a micro flaw or a finishing defect on the surface of the product being examined has not been detected. In order to examine a surface of a product it is known to use a lighting unit having a plurality of illuminants, such as light-emitting diodes, placed along the underside of the lighting unit so that the entire underside thereof emits light areally in order to keep the light intensity on the surface to be examined even. This is especially true when a product to be examined is three-dimensional. In this case, it is necessary to light up the product to be examined from several directions, not only one direction, as if to cover the

product with light. In such a case it is usual to use a lighting unit having an underside, namely the surface which emits light, that is a concave face of a hollow truncated cone shape and that has a plurality of illuminants arranged on the concave face.

However, if a lighting unit has the above-mentioned arrangement, in order to place a plurality of illuminants all over the underside of the lighting unit, complicated steps have to be taken, such as processing the underside of the lighting unit to form a concave face of a hollow truncated cone or a hollow conic, perforating a plurality of holes on the concave face, embeding illuminants in each of the holes respectively, and then wiring each of the illuminants by hand. These steps make it difficult and time consuming to assemble the lighting unit having the above-mentioned arrangement. This also makes it more difficult to standardize a process of manufacturing a variety of lighting units having different angles for emitting light because every step, such as processing the underside of the lighting unit or the angle of a hole perforation, varies.

It is an object of the present invention to provide a method of manufacturing a lighting unit characterized by the lighting unit having a plurality of illuminants set up on a concave face of a hollow truncated cone shape that can be easily manufactured.

## SUMMARY OF THE INVENTION

In order to accomplish the above-mentioned object, the invention includes a method of manufacturing a lighting unit comprising the steps of holding a flexible circular board having a concentric circular hole and a cutout which has at least two sides in a planar state, embedding a plurality of illuminants in the board, and jointing one side of the cutout and the other side of the cutout or holding both sides of the cutout in close contact so as to place the illuminants in the side of the concave face. With the above-mentioned method, a plurality of illuminants can easily be set up on a concave face of the hollow truncated cone-shaped board.

More specifically, the invention is a method of manufacturing a lighting unit in which a plurality of illuminants are arranged on a concave face of a board formed into the shape of a hollow truncated cone. The illuminants are mounted on the underside of the lighting unit through the board by the steps of holding the flexible circular board having a concentric circular hole and a cutout with at least two sides in a planar state, embedding a plurality of illuminants such as light-emitting diodes or the like in the board, and then jointing one side of the cutout and the other side of the cutout of the board or holding both sides of the cutout in close contact.

In particular, in order to further simplify assembling operations, it is preferable to use a printed circuit board as the above-mentioned board so that the operations of wiring each illuminant and embedding each illuminant in a board can be done at one time.

In accordance with the invention, the following effects are achieved.

It becomes possible to easily set up a plurality of illuminants on a concave face of a hollow truncated cone-shaped board by the following steps. First, a flexible circular printed circuit board having a concentric circular hole and a cutout which has at least two sides is held in a planar state. Next, a plurality of illuminants are embeded in the board. Finally, one side of the cutout and the other side of the cutout are jointed together or both sides of the cutout are held together in close contact so as to place the illuminants in a side of the concave face. As a result of this, a complicated process is avoided when forming the underside of the lighting unit, assembly of the lighting unit is made easier, and the time required to assemble the lighting unit is shortened. In addition, the angle of emittance of the lighting unit can easily be changed just by changing the diameter of the board or the size of the cutout. As a result, it is easy to manufacture a variety of lighting units

each with a different angle of emitting light so that the light can fit the product being examined.

If a printed circuit board is used as the board, the wiring operation is completed just by embedding the illuminants in the board. This simplifies the process of assembling the lighting unit because a complicated process step, such as wiring each of the illuminants, can be omitted.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

The objects and features of the invention may be understood with reference to the following detailed description of illustrative embodiments of the invention, taken together with the accompanying drawings in which;

Fig. 1 is a cross sectional end view of a lighting unit showing a preferred embodiment of this invention,

Fig. 2 is a front view showing the board on which illuminants are mounted prior to assembling the lighting unit shown in Fig. 1,

Fig. 3 is a cross sectional end view of a lighting unit showing a modification of the preferred embodiment, and

Fig. 4 is a front view showing the board on which illuminants are mounted prior to assembling the lighting unit shown in Fig. 3.

## **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

An embodiment of the invention will now be described below with reference to Fig. 1 and Fig. 2.

As shown in Fig. 1, a plurality of illuminants 1 such as light-emitting diodes are arranged on an underside of a lighting unit 4, namely on a concave face 2c of a hollow truncated cone-shaped flexible printed circuit board 2. A lighting case 3 holds the illuminants 1 together with the board 2. Power is supplied to each of the illuminants 1 from a power cable 5 extending through the board 2. The lighting case 3 is provided with a center hole 32 for visual inspection or taking photos of the surface to be inspected. A frame 33 is used to retain the illuminants 1 and the board 2. An internal thread 31 formed in the lighting case 3 is for mounting the lighting unit 4.

With the above-mentioned arrangement, a method of manufacturing a lighting unit in accordance with the invention will now be explained. First, the flexible printed circuit board 2 is held in a planar state. The shape of the board 2 is a circle with a concentric circular hole and a cutout having two sides 2a, 2b. Next, the illuminants 1 are embeded in the board 2 by soldering or the like. Then, one side 2a of the cutout and the other side 2b of the cutout are jointed together or both sides 2a, 2b of the cutout are kept in close contact so as to

place the illuminants 1 in the side of the concave face 2c. As a result, the board 2 is inevitably transformed into a shape of a hollow truncated cone and the illuminants 1 are set up on the concave face 2c of the hollow truncated cone-shaped board 2, as shown in Figs. 1 and 3. At the same time, a power cable 5 is wired into the board 2 by soldering or the like. Finally, the formed board 2 and illuminants 1 are mounted to the lighting case 3 through the frame 33, thereby to manufacture the lighting unit 4.

In accordance with the above-mentioned method of manufacturing the lighting unit 4, it is possible to embed the illuminants 1 in the board 2 when the board 2 is in a planar state. Therefore, in this case the same method used to mount electrical parts on an ordinal printed circuit board can be applied to the lighting unit 4 of the present invention. In addition to that, since the printed circuit board 2 is used as the board, the step of individually wiring each illuminant 1 can be omitted. Instead, the illuminants 1 can be embedded in the board 2 by soldering or the like. As a result, the process of assembling the lighting unit 4 is simplified. When one side 2a of the cutout and the other side 2b of the cutout are jointed or both sides 2a, 2b of the cutout are kept in close contact so as to place the illuminants 1 in the side of a concave face, the

board 2 is bent and inevitably transformed into the shape of a hollow truncated cone. This shape makes it easy to arrange the illuminants 1 on the concave face 2c of the hollow truncated cone-shaped board 2. Thus, formed board 2 and illuminants 1 are easily mounted to the underside of the lighting case 3 through the frame 33. Also, there is no need for processing the lighting case 3 into a shape of a concave portion of a conic or a truncated cone nor a need for perforating holes in the printed circuit board to embed the illuminants. As shown in Figs. 3 and 4, a hollow truncated cone shape having an arbitrary size and angle can easily be formed just by changing a diameter of the board 2 or size of the cutout. In addition, the light emitting angle can easily be changed just by changing the frame 33 tailored to fit the truncated cone shape, namely by changing only a part of the lighting unit.

This invention is not limited to the embodiments described in detail hereinabove. For example, the board 2 may be a shape of an ellipsoid having a cutout to vary a shape of a light emitting surface.

Moreover, each of the arrangements is not limited to that illustrated in the figures and there may be various modifications without departing from the spirit and essential characteristics thereof.